Contents

Preface v

Conference Organization vii

Contents ix

CORROSION AND OXIDATION APPLICATIONS

Surface modification of iron and steel by zirconium or yttrium ion implantation and their electrochemical properties 1
M. Iwaki, K. Takahashi (Saitama, Japan), T. Hayakawa, M. Yuasa, I. Sekine (Noda, Japan), J. Takahashi, K.-I. Terashima (Chiba, Japan) and B. V. Crist (Tokyo, Japan)

Chemical and structural effects of phosphorus on the corrosion behavior of ion beam mixed Fe–Cr–P alloys 6
J. D. Demaree, G. S. Was (Ann Arbor, MI, USA) and N. R. Sorensen (Albuquerque, NM, USA)

Effect of target temperature during carbon implantation on the composition and electrochemical properties of iron surface layers 13
A. Sekiguchi, M. Yuasa, I. Sekine, K. Akashi (Noda-shi, Japan), T. Fujihana (Urawa-shi, Japan), K. Takahashi and M. Iwaki (Wako-shi, Japan)

Effects of room temperature carbon, nitrogen and oxygen implantation on the surface hardening and corrosion protection of iron 19
T. Fujihana (Urawa-shi, Japan), A. Sekiguchi (Noda-shi, Japan), Y. Okabe (Ohsato, Japan), K. Takahashi and M. Iwaki (Wako-shi, Japan)

Microstructure and corrosion of nitrogen implanted AISI 304 stainless steel 24
M. E. Chabica, D. L. Williamson (Golden, CO, USA), R. Wei and P. J. Wilbur (Fort Collins, CO, USA)

The pitting behavior of silicon nitride ion beam assisted deposited coatings on aluminum 30
P. M. Natishan, E. McCafferty, E. P. Donovan, D. W. Brown and G. K. Hubler (Washington, DC, USA)

Studies of surface composition and electrocatalytic activity of titanium cathodes implanted with Ni^+ 35
J. Jin, Z. Xie, J. Li (Hunan, China), L. Zheng (Guangdong, China) and Y. Chen (Sichuan, China)

Electrocatalytic protection against hydrogen embrittlement of tantalum in strong acids by platinum ion implantation 41
W. Ensinger and G. K. Wolf (Heidelberg, FRG)

Secondary ion mass spectrometry and scanning transmission and transmission electron microscopy studies of the effects of reactive elements on nickel oxidation 45
P. J. George (Harayana, India), M. J. Bennett, H. E. Bishop (Didcot, UK), C. M. Cotell (Washington, DC, USA) and A. J. Garratt-Reed (Cambridge, MA, USA)

A study of high temperature oxidation of nickel after ion implantation 52
Z. Rao, J. S. Williams (Canberra, ACT, Australia) and D. K. Sood (Melbourne, Vic., Australia)

External oxidation of aluminium–lithium alloys 57
D. Fink, J. T. Zhou (Berlin, FRG), V. Hnatowicz, J. Kvitek and V. Havranek (Prague, Czechoslovakia)

The influence of cerium ion implantation on chromium oxidation 65
M. J. Bennett, A. T. Tuson, D. P. Moon, J. M. Titchmarsh (Didcot, UK), P. Gould and H. M. Flower (London, UK)

Distribution of ion-implanted yttrium in Cr_2O_3 scales and in the underlying Ni-25wt.%Cr alloy 73
P. Hou, I. Brown (Berkeley, CA, USA) and V. Chia (Redwood City, CA, USA)

WEAR AND MECHANICAL PROPERTY APPLICATIONS

Synthesis and stability of nitride layers in iron by megaelectronvolt nitrogen implantation 79
A. M. Vredenberg, C. M. Pérez-Martin, J. S. Custer, D. O. Boerma, L. de Wit, F. W. Saris (Amsterdam, Netherlands), N. M. v/d Pers, Th.H. de Keijser and E. J. Mittemeijer (Delft, Netherlands)

Physicochemical and tribological characterization of titanium or titanium plus carbon implanted AISI M2 steel 87
M. A. El Khakani, G. Marest, N. Moncoffre and J. Tousset (Villeurbanne, France)

The interdependency of microstructure, stress and wear for ion beam modified tool steels 93
M. Hans, H. Martin, H. Ollendorf, G. K. Wolf (Heidelberg, FRG) and D. Boos (Stuttgart, FRG)

High temperature nitrogen implantation of Ti–6Al–4V
I: Microstructure characterization 100
F. M. Kustas, M. S. Misra (Denver, CO, USA), R. Wei, P. J. Wilbur (Fort Collins, CO, USA) and J. A. Knapp (Albuquerque, NM, USA)

High temperature nitrogen implantation of Ti–6Al–4V
II: Tribological properties 106
F. M. Kustas, M. S. Misra (Denver, CO, USA), R. Wei and P. J. Wilbur (Fort Collins, CO, USA)

Ion implantation effects on fatigue properties of Fe–13Cr–15Ni alloys 112
G. R. Rao, E. H. Lee (Oak Ridge, TN, USA) and B. A. Chin (Auburn, AL, USA)

Solid lubricating films produced by ion bombardment of sputter deposited MoS_x films 118
N. J. Mikkelsen and G. Sørensen (Aarhus, Denmark)

Reduction of friction and wear by ion-implanted carbonized photoresist 124
R. Öchsner, A. Kluge, S. Bogen, H. Ryssel (Erlangen, FRG) and J. Gyulai (Budapest, Hungary)

Ion-beam-enhanced adhesion of iron films to sapphire substrates 129
J. E. Pawel, L. J. Romana (Oak Ridge, TN, USA), C. J. McHargue (Knoxville, TN, USA) and J. J. Wert (Nashville, TN, USA)

Tribological and microstructural studies of oxygen-implanted ferrite and austenite 133
R. Wei, P. J. Wilbur (Fort Collins, CO, USA), O. Ozturk and D. L. Williamson (Golden, CO, USA)
The effects of beam energy and substrate temperature on the tribological properties of hard-carbon films on aluminum 139
R. Wei, P. J. Wilbur (Fort Collins, CO, USA), A. Erdemir (Argonne, IL, USA) and F. M. Kustas (Denver, CO, USA)
Adhesion, friction and wear between polytetrafluoroethylene and nitrogen-implanted stainless steel 146
E. Yang, M. Räsänen (Helsinki, Finland), J.-P. Hirvonen and R. O. Toivanen (Espoo, Finland)
Enhanced wear resistance of production tools and steel samples by implantation of nitrogen and carbon ions 152
N. J. Mikkelsen and C. A. Straede (Aarhus, Denmark)
Effects of ion implantation and plasma treatment on tribological properties of aluminium and Al–Mg alloy 157
K.-i. Nomoto, S. Nishijima, K. Katagiri, M. Nunogaki, T. Nishiura, T. Okada, H. Mori and K.-i. Iwamoto (Osaka, Japan)
Ion beam induced atomic mixing at the Ti–C interface and its implications for mechanical properties 162
B. G. Wagh (Nasik, India), N. Mate, S. M. Kanetkar and S. B. Ogale (Pune, India)
Implantation of titanium, chromium, yttrium, molybdenum, silver, hafnium, tantalum, tungsten and platinum ions generated by a metal vapor vacuum ion source into 440C stainless steel 166
J. Sasaki, K. Hayashi, K. Sugiyama, O. Ichiko (Sagamihara, Japan) and Y. Hashiguchi (Kawasaki, Japan)
Ion implantation of titanium alloys for improved fretting resistance 176
J. E. Berry, E. J. Tobin and P. Sioshansi (Bedford, MA, USA)
Wear resistance of ion-implanted metallic materials 180
I. B. Kurakin, A. E. Ligachov, J. E. Remnev and M. G. Sipailo (Moscow, Russia)
Structural changes of materials modified by ion beams and the nature of their hardening 186
A. N. Didenko, A. E. Ligachov, I. B. Kurakin, M. G. Sipailo (Moscow, Russia), E. V. Kozlov and J. B. Sharkeev (Tomsk, Russia)

ION BEAM ASSISTED DEPOSITION: TECHNIQUES AND APPLICATIONS

Boron nitride films synthesized by ion-beam-assisted deposition 190
D. Bouchier (Orsay, France) and W. Möller (Garching, FRG)
Characteristics of TiO_2 coatings produced by the reactive ionized cluster beam method 197
K. Fukushima (Osaka, Japan) and I. Yamada (Kyoto, Japan)
Low energy ion-assisted deposition of metal films 203
R. Roy (Yorktown Heights, NY, USA)
Nb–Cr alloy coatings produced by ion-beam-assisted deposition 212
J. H. Hsieh, W. Wu, R. A. Erck, G. R. Fenske (Argonne, IL, USA), Y. Y. Su and M. Marek (Atlanta, GA, USA)
Are coatings produced by ion-beam-assisted deposition superior? A comparison of chemical and mechanical properties of steel coated using different deposition techniques 217
W. Ensinger, A. Schröer and G. K. Wolf (Heidelberg, FRG)
Microstructure and corrosion behaviour of chromium nitride grown by dynamical ion beam mixing 222
Z. Chen and S. Patu (Shenyang, China)
Protective behaviour against high temperature oxidation of silicon nitride films synthesized by ion-beam-assisted deposition 227
Y. Chen, S. Liu, Z. Shang, C. Xu, Y. Zheng (Sichuan, China), X. Liu and S. Zou (Shanghai, China)
Effect of a titanium nitride interlayer on the endurance and composition of a molybdenum disulfide coating prepared by ion-beam-assisted deposition 232
L. E. Seitzman, I. L. Singer, R. N. Bolster (Washington, DC, USA) and C. R. Gossett (Landover, MD, USA)
Ion-beam-assisted deposition and ion beam synthesis of wear resistant coatings on technical surfaces 237
A. Kluge, B. H.-S. Javadi, R. Öchsner, H. Ryssel (Erlangen, FRG) and H. Ruoff (Stuttgart, FRG)
Microstructure modificatons during early stages of ion-beam-assisted film growth of germanium on SiO_2 243
S. Nikzad and H. A. Atwater (Pasadena, CA, USA)
Kinetics of ion beam deposition of carbon at room temperature 247
R. A. Kant and G. K. Hubler (Washigton, DC, USA)
Investigation of ZrN thin film prepared by dynamic mixing 252
X.-Y. Wen and Z.-L. Zhang (Dalian, China)

NOVEL TECHNIQUES AND APPLICATIONS

Synthesis and characterization of diamond-like carbon films for optical and mechanical applications 258
R. L. C. Wu (Dayton, OH, USA)
Hardness and wear properties of boron-implanted poly(ether-ether-ketone) and poly-ether-imide 267
Y. Lee, E. H. Lee and L. K. Mansur (Oak Ridge, TN, USA)
Technological development of soft X-ray mirror in the Advanced Material Processing and Machining Technology Research Association (AMMTRA) 273
I. Kataoka (Tokyo, Japan)
Current issues in cold fusion research: heat, helium, tritium, and energetic particles 283
S. E. Jones (Provo, UT, USA)
Pulsed laser deposition of electronic ceramics 290
J. S. Horwitz, D. B. Chrisey, K. S. Grabowski and R. E. Leuchtner (Washington, DC, USA)
Ion beam treatment of potential space materials at the NASA Lewis Research Center 299
M. Kussmaul (Brookpark, OH, USA), M. J. Mirtich and A. Curren (Cleveland, OH, USA)

The effect of carbon ion implantation on the nucleation of diamond on Ti–6Al–4V alloy 307
D. K. Sood (Melbourne, Australia), W. R. Drawl and R. Messier (University Park, PA, USA)
Characterization study of nitrogen-ion-implanted amorphous bright chromium deposited films 313
H. Ferber (Stuttgart, FRG), C. K. Mount, G. B. Hoflund (Gainesville, FL, USA) and S. Hoshino (Tokyo, Japan)
Optical waveguides in polymeric materials by ion implantation 318
D. M. Rück, S. Brunner, W. Frank (Darmstadt, FRG), J. Kulisch and H. Franke (Duisberg, FRG)

FUNDAMENTALS

A molecular dynamics analysis of low energy atom–surface interaction during energetic deposition of silver thin films 324
C. M. Gilmore and J. A. Sprague (Washington, DC, USA)
Simulation of deposition and densification in an ion beam environment 328
T. D. Andreadis, M. Rosen, M. I. Haftel and J. A. Sprague (Washington, DC, USA)
Application of a thermal spike model to experimental ion-induced grain growth data 333
D. E. Alexander (Argonne, IL, USA) and G. S. Was (Ann Arbor, MI, USA)
Trapping, diffusion and release of helium in single-crystal TiC observed by thermal desorption spectrometry 338
W. H. B. Hoondert, B. J. Thijsse, A. van Veen and A. van den Beukel (Delft, Netherlands)
Ion-beam mixing with chemical guidance
II: Analysis for positive heats of mixing 343
R. Kelly (Yorktown Heights, NY, USA) and A. Miotello (Povo, Italy)
On the three-dimensional shapes of ion implantation distributions 352
D. Fink and M. Müller (Berlin, FRG) ,
Depth profiles, projected ranges, and secondary ion mass spectrometry relative sensitivity factors for more than 50 elements from hydrogen to uranium implanted into metals 358
R. G. Wilson (Malibu, CA, USA), F. A. Stevie (Allentown, PA, USA), G. E. Lux, C. L. Kirschbaum, S. Frank and J. Pallix (Redwood City, CA, USA)
Anomalous ranges of ions implanted into carbon 364
G. Dearnaley, J. L. Ing, S. Sugden (Didcot, UK), I. G. Brown and X. Godechot (Berkeley, CA, USA)
Study of the dynamic processes involved during nitrogen implantation into aluminum 368
G. Terwagne and S. Lucas (Namur, Belgium)
20 keV–40 MeV lithium implantation profiles in aluminium 372
L. Wang, K. Tjan, D. Fink, P. Goppelt, M. Briére (Berlin, FRG) and J. P. Biersack (Erlangen, FRG)
Reactivity of palladium ions implanted into Nb_2O_5 layers and the Frenkel defects produced 379
T. Patzelt, J. W. Schultze (Düsseldorf, FRG), O. Meyer (Karlsruhe, FRG) and J. L. Delplancke (Brussels, Belgium)
Charge injection properties of iridium oxide films produced on Ti–6Al–4V alloy substrates by ion beam mixing techniques 385
J. M. Williams (Oak Ridge, TN, USA), I. S. Lee and R. A. Buchanan (Knoxville, TN, USA)
Surface topography of $^{40}Ar^+$ and $^{84}Kr^+$ bombarded copper, silver and nickel 392
S. R. Bhattacharyya, T. K. Chini and D. Basu (Calcutta, India)
Self-ion sputtering yield determinations of (100) nickel thin films 399
J. K. Steele, C. H. Koch and D. I Potter (Storrs, CT, USA)
In situ investigation of sputter-deposited thin films by ion sputtering spectrometry 405
Y.-s. Ku and C.-s. Su (Hsinchu, Taiwan)

PHASE STABILITY IN ION IMPLANTED MATERIALS

Formation of small metallic precipitates of niobium in α-Al_2O_3 implanted with niobium ions 410
L. Romana, P. Thevenard, S. Ramos, B. Canut, L. Gea (Villeurbanne, France), M. Brunel (Grenoble, France), L. L. Horton (Oak Ridge, TN, USA) and C. J. McHargue (Knoxville, TN, USA)
Formation and annealing behavior of an amorphous layer induced by tin implantation into sapphire 415
L. J. Romana, P. S. Sklad, C. W. White, J. C. McCallum, A. Choudhury, L. L. Horton and C. J. McHargue (Oak Ridge, TN, USA)
Phase transformations in phosphorus ion implanted 304L stainless steel 420
E C. Cooney and D. I. Potter (Storrs, CT, USA)
Effects of ion beam and pulsed laser irradiation on Fe–Cu multilayers 429
A. Gupta (Indore, India), G. Principi, P. Trotta, E. Jannitti, S. Lo Russo, V. Rigato (Padua, Italy), C. Tosello, L. M. Gratton (Trento, Italy) and S. Enzo (Venice, Italy)
High-temperature implantation of gold into nickel 435
M. R. James, N. Q. Lam, L. E. Rehn, P. M. Baldo, L. Funk (Argonne, IL, USA) and J. F. Stubbins (Urbana, IL, USA)
Computer simulations and transmission electron microscopy investigations of nitrogen implanted into aluminium at high temperature . 441
S. Lucas (Namur, Belgium) and J. Chevallier (Aarhus, Denmark)
Boron implantation into AISI 52100 steel 446
N. Millard, G. Marest, N. Moncoffre and J. Tousset (Villeurbanne, France)
Krypton ion and pulsed laser-induced reactions in the Fe–Si system 451
A. Gupta, R. Gupta (Indore, India), G. Principi, E. Jannitti, S. Lo Russo, V. Rigato (Padua, Italy), C. Tosello, L. M. Gratton (Trento, Italy) and R. Frattini (Venice, Italy)

Formation of intermetallic compounds with a high flux pulse molybdenum ion beam in steel and aluminium 455
T. Zhang, C. Ji, J. Yang, J. Chen, J. Shen, W. Lin, Y. Gao and G. Sun (Beijing, China)
Diffusion behaviour of lead implanted into aluminium 461
A. Johansen, E. Johnson, L. Sarholt-Kristensen, S. Steenstrup, L. Yu and K. K. Bourdelle (Copenhagen, Denmark)
Phase composition of chromium films deposited under nitrogen ion bombardment and their corrosion protection potential 466
W. Ensinger, A. Schröer, C. Klatt (Heidelberg, FRG), M. Kiuchi, Y. Horino, A. Chayahara, K. Fujii, M. Satou (Osaka, Japan) and R. Leutenecker (Munich, FRG)
Ion bombardment, ultrasonic, and pulsed laser beam effects on small metallic clusters of potassium in MgO 471
J. Rankin, P. Thevenard, L. J. Romana, L. A. Boatner, C. W. White, L. L. Horton (Oak Ridge, TN, USA) and C. J. McHargue (Knoxville, TN, USA)
The preparation of epitaxial platinum films by pulsed laser deposition 476
R. E. Leuchtner, D. B. Chrisey, J. S. Horwitz and K. S. Grabowski (Washington, DC, USA)
The effect of the angle of incidence on the aqueous corrosion of ion implanted M50 steel substrates 483
C. M. Rangel, M. H. Simplicio, A. C. Consiglieri, J. C. Soares (Lisbon, Portugal), B. R. Nielsen, B. Torp (Jyllinge, Denmark), N. Teixeira, J. G. Alves, M. F. Silva (Sacavém, Portugal), A. Dodd and J. Kinder (Newark, UK)

INDUSTRIAL APLICATIONS AND TECHNIQUES

Plasma immersion ion implantation: duplex layers from a single process 489
R. Hutchings, G. A. Collins and J. Tendys (Menai, NSW, Australia)
The effect of ion implantation on the lifetime of punches 495
R. Öchsner, A. Kluge, H. Ryssel (Erlangen, FRG), M. Stepper (Pforzheim, FRG), Chr. Straede (Aarhus, Denmark) and J. Politiek (Eindhoven, Netherlands)
Ion bombardment of AlN films deposited in a reactive sputtering process with accurate control of the mass flow of the reactive gas . . . 500
K. Alkjærsig, H. B. Christensen, B. K. Gupta, H. Jensen, U. M. Jensen, G. N. Pedersen and G. Sørensen (Aarhus, Denmark)
Effects of ion beam bombardment of carbon thin films deposited onto tungsten carbide and tool steels 509
K. Awazu, H. Yoshida (Ishikawa, Japan), H. Watanabe (Tokyo, Japan), M. Iwaki and L. Guzman (Saitama, Japan)

Current Industrial Practices

Surface modification and other advanced ion beam processing projects in Japan 514
I. Yamada (Kyoto, Japan)
Surface modification of stainless steel in coil by an in-line dry coating process 522
T. Takahashi, Y. Oikawa, T. Komori (Yamaguchi, Japan), I. Ito (Tokyo, Japan) and M. Hashimoto (Kanagawa, Japan)
Versatile high current metal ion implantation facility 529
I. G. Brown, M. R. Dickinson, J. E. Galvin, X. Godechot and R. A. MacGill (Berkeley, CA, USA)
Metal vapour vacuum arc source ion implantation as a surface treatment technique for industrial tool bits 534
W. L. Lin, X. J. Ding, H. X. Zhang, J. M. Sang, J. Xu and Z. Y. Wang (Beijing, China)
Ion implantation as an industrial process 540
M. E. Boston (Cambridge, UK) and K. O. Legg (Evanston, IL, USA)
Performance of the advanced MEVVA®IV 80–10 metal ion implantation system 546
J. R. Treglio, G. D. Magnuson and R. J. Stinner (San Diego, CA, USA)
Modification technology of N^+ implantation of carbide twist drills used in printed circuit boards and its industrial application 551
G. Man, S. Tao, X. Shao, L. Shen, H. Zheng (Sichuan, China), Y. Yun, X. Zhang and Z. Lin (Shanxi, China)
A computerized end-station for a high-current ion implanter 556
B. Torp, P. Abrahamsen, S. Eriksen and B. R. Nielsen (Jyllinge, Denmark)

Author Index 561

Subject Index 563